

A Work Project, presented as part of the requirements for the Award of a Master's Degree in Finance from the *NOVA School of Business and Economics*.

The Yield Curve as a Predictor of Recessions in the Euro Area A Multicountry Analysis

João Pedro de Brito Cruz, nº 864

A Directed Research Project carried out under the supervision of:

Professor João Pedro Pereira

May 2016

Abstract

This paper revisits the role of the yield spread to forecast recessions in the Euro Area. We show that the contribution of the spread can be decomposed into the effect of future expected changes in short term rates and the effect of the term premium. This decomposition is achieved with the use of a no arbitrage affine term structure model incorporating two latent factors that explain level and slope movements in the yield curve. We find that the expectations hypothesis component accounts for most of the predictability of the spread with part of this predictability reflecting the effects of the monetary policy stance. The results suggest, however, that the yield spread predictive content is driven by other factors independent of monetary policy.

Keywords: Yield Spread, Expectations Component, Term Premium, Monetary Policy

1. Introduction

The slope of the yield curve has long been recognized as a leading indicator in predicting future macroeconomic conditions and particularly recessions. Historically the inversion of the yield spread has provided a positive statistical relationship with the odds of future recessions, and thus is widely viewed as a signal for an economic downturn both in Europe and in the U.S.¹ Despite their wide use, several studies claim that the predictive relationship between the yield spread and future recessions may be unstable over time, particularly when economic activity is measured in terms of economic growth and therefore as a continuous time variable (See Estrella, Rodrigues and Stich 2003).

The issue of instability in the relationship between the yield spread and future economic growth has recently come to the attention of monetary authorities and financial market participants in general. This increasing interest has been prompted by the developments in the United States during the Conundrum period where long term interest rates fell in a period of gradual monetary tightening by the Federal Reserve, leading to a flattening of the yield curve, both from the long and shorter ends of the curve. This unusual behavior of long term interest rates and the yield curve is reinforced by the fact that it occurred in a period of continuing economic growth, while the flattening of the curve used to signal a downturn in economic activity and an eventual recession.

The main reason put forward to explain the breakdown of the yield spread in predicting economic activity is the unusual time varying nature of the term premium. The decline in long term interest rates was mostly driven by a declining term premium rather than lower expectations of average future short term interest rates, as predicted by the expectations hypothesis of the yield curve. Nevertheless, the idea that the term premium is distorting the

¹ See for example Estrella and Hardouvelis (1991), Estrella and Mishkin (1996,1998) for the U.S and Fabio Moneta for the Euro Area. The yield spread has also been used as a leading indicator in several widely followed leading indexes in the U.S, including the Stock and Watson (1989) Recession Index to predict turning points in the Business Cycle and the U.S Conference Board Leading Coincident Index

information content of the spread implicitly assumes that its predictive content mainly stems from the expectations component rather than the term premium. This is an empirical issue, however, and we cannot exclude the possibility that the term premium might have the same information content for real economic activity as the expected spread. In such case, it would be irrelevant, in terms of predictive content, whether changes in the yield spread were driven by changes in the term premium or changes in the expectations component of the spread.

This paper addresses empirically the role of each of the components of the spread in predicting future recessions in four Eurozone countries (Germany, Italy, Spain and Netherlands). The predictive power of the spread is evaluated with the use of probit models, where recessions are estimated using the Bry and Boschan algorithm (1971), due to the lack of official recession dates for individual Euro area countries. For the purposes of decomposing the yield spread, the spread is constructed as the difference between ten year bond yields and three month interbank rates and separated into an expectations and a term premium components. The expectations component measures the difference between the average of future expected three month interest rates over the ten years period and the current three month interest rate and is estimated with a discrete affine term structure model with two factors. Such structure is chosen for its parsimony, closed form solutions and good out of sample forecasting properties (see Ang and Piazzesi 2003). The term premium on ten year bonds, which bears the extra risk associated with holding long term bonds, is then estimated by removing from the yield spread its expectations component.

By separating the effects of each of the spread's components, we may also improve the information signal of the yield spread in predicting recessions. If, for instance, its predictive content derived mostly from the expectations component, it would claim for a dominant role of future expected short term interest rates relative to current interest rates, and hence of monetary policy. In such case the term premium is contaminating the signal of the expectations

component and removing it from the spread leads to better recession forecasts. Otherwise, if a role to the term premium could also be granted, then including the effects of both components in the model might contribute to improve its forecasting accuracy. Intuitively, this makes sense as the term premium reflects the risk and uncertainty associated with holding long term bonds, which may change due to financial market participant's perception of macroeconomic risk. In this sense, the term premium tends to be linked to future business cycles, as investors may be more risk averse in anticipation of a future recession than in an economic boom.

The decomposition of the term spread into an expectations and term premium components to individually assess their predictive content is not new in the literature. In the U.S, Hamilton and Kim (2000) find that both expected changes in interest rates and the term premium contain predictive content for GDP growth, though the expectations component significantly dominates the effect of the term premium. In an alternative framework, John Wright [2006] uses the Cochrane and Piazzesi's return forecasting factor to test the forecasting ability of the spread to predict recessions in the U.S. This measure consists of a single linear combination of forward treasury rates and has shown a high correlation with the expected excess returns of long term bonds (See Cochrane and Piazzesi 2005). However, the term premium measure does not enter statistically significant and adds little extra explanatory power to the probit models. Most recently Rosenberg and Maurer [2008] extended the work of Wright, by assessing the predictive content of each of the spread's components in predicting U.S. recessions. The results are consistent with Wright's and show that the yield curve signal comes mostly from its expectations component, while the term premium measure has no explanatory power when considered in isolation.

To our knowledge, the idea of decomposing the spread for forecasting recessions in the Euro Area has not previously been taken. The paper closest to our methodology for Europe is that of Kremer and Werner (2006), which empirically address the role of both components in

predicting future changes in industrial production in Germany. In their predictive regressions, the expectations hypothesis tracks very closely the simple spread, while the term premium only enters statistically significantly for longer forecasting horizons.

Our paper complements the current literature in three ways. In the first place, the paper is the first to apply the idea of decomposing the term spread for forecasting recessions in Euro Area countries. Second, the paper explores the linkages between the yield spread and monetary policy, namely providing insights on whether monetary policy effects explain the predictive content of the yield spread. Third, we test for possible structural breaks between the yield spread and future recessions across different forecasting horizons.

2. Predictive Content of the yield spread for real economic activity

This section presents the theoretical support that explains the relationship between the yield spread and real economic growth, and consequently why the yield spread might contain informational content for future recessions. In general the relationship is positive and essentially reflects market participant's expectations of future economic growth. A steepening of the yield spread is associated with a rise in real economic activity and lower odds of a future recession while a flattening of the spread signals a slowdown in economic activity and a higher likelihood of a future recession.

The explanations for the informational content of the yield spread are at least three and are mostly grounded on the expectations hypothesis of the yield curve. In the presence of the expectations hypothesis (and neglecting the term premium) the term spread measures the difference between market participants future expected short term rates and the current short term interest rate, which tends to move closely with monetary policy actions. The term spread is thus an indicator of the current stance of monetary policy relative to future expected monetary policy. A lower spread, for example, with short term rates rising relative to long term rates

signals a relatively more restrictive current monetary policy stance and consequently the higher are the odds of a recession in the following quarters.

A second explanation for the predictive content of the spread is offered by Bernard and Gerlach (1996) and is based on the different reactions of short term yields and long term yields to monetary policy actions. Short term yields tend to move much more closely with monetary policy actions than long term yields. As Bernard and Gerlach (1996) argue, since monetary policy actions are regarded as temporary by market participants, agents will change their expectations of future interest rates by less than the initial change in the current short rate. Thus, when the central bank tightens monetary policy, long term yields will rise by less than short term rates and the yield spread will flatten. From this perspective, the yield spread predicts future recessions as it reflects the effects of current monetary policy and real economic growth responds to monetary policy actions. A more forward looking argument that goes beyond the role of the spread as an indicator of current monetary policy actions is proposed by Hamilton and Kim (2000). The market expectations of future growth can be signaled by the yield spread through future expected short term rates. If, for instance, market participants anticipate an upcoming recession and lower rates of return to investment, expected future short rates will fall below the current short term rates and thereby the yield on long term bonds will decrease relative to short term yields.

The correlation between the nominal yield spread and real economic activity implicitly presupposes that the nominal yield spread reflects real spreads, which ultimately drive real economic activity. The predictive content of the yield spread thereby depends on the time series path of future expected inflation and on whether expected inflation changes distort the signal of the yield spread. In this respect, Bordo and Haubrich (2004,2008) show that the term spread tends to forecast better real activity during periods of high inflation persistence. In those periods, inflation is close to a random walk and, as such, shocks to inflation raise equally short

term and long term nominal interest rates, leaving the yield spread unchanged. Conversely, the term spread forecasts less accurately economic growth in periods of low inflation persistence, in which inflation shocks increase more near-term expected inflation than long term inflation, causing the slope of the nominal curve to change and thereby distorting its information signal. Since the patterns of inflation differ across countries and monetary regimes, the predictive content of the yield spread should be affected by the nature of inflation. Particularly, the term spread is likely to be a better indicator of future recessions in countries with high and variable inflation than in countries with low and stable inflation.

Apart from changes in the expected real future short term rates and changes in expected inflation, term spread movements can also be originated by a changing term premium, which reflects the interest rate risk and uncertainty associated with holding long term bonds. The premium for holding long term bonds will depend on the price and the amount of risk, which may change due to economic agent's perceptions of macroeconomic uncertainty (DH Kim 2005). For example, the degree of systematic risk may change with changing perceptions of uncertainty around future inflation, real economic activity and future monetary policy. In this sense, the risk premium is an indicator of the investor's sentiment, which in turn is correlated with consumer and business sentiment. Accordingly, the term premium tends to be linked to future business cycles, as investors may be more risk averse in anticipation of a future recession than in an economic boom. Also, if for instance the term premium declines due to better anchored inflation expectations or a reduction in the volatility of real economic activity, it may contribute to lower long term interest rates, thus stimulating spending and causing economy to grow.

The different implications of the term spread's components to economic growth require that we consider its effects separately, particularly because they may ask for different policy actions from monetary authorities. For instance, to the extent that long term rates have fallen

due to a declining term premium, the effect is stimulating by acting as a special factor that lowers the spread between long term and short term interest rates. In that sense, the required policy rate associated with a given degree of financial stimulus from monetary authorities is now higher and requires a restraint in monetary policy. However, if long term rates have fallen due to lower future expected short term interest rates, this may reflect investor's expectations of a future economic slowdown. In anticipation of a recession, economic agents will mark down their expected path of future short term rates as they expect lower rates of return to investment and a future monetary policy easing to stimulate the economy. In that case, a looser current monetary policy would be required to counteract this effect.

3. Estimating the Term Premium

3.1 A Two factor affine term structure model with latent factors

To estimate the dynamics of the yield curve, we follow Duffie and Kan (1996), Dai and Singleton (2002) and Ang, Piazzesi and Wei (2003) and develop a discrete affine term structure model with two latent factors. These models assume that bond yields depend linearly on the evolution of a set of unobservable factors, in a way that no arbitrage is ensured across the entire term structure. The affine term structure model contains three basic equations.

The first equation is the transition equation that models the dynamics of the vector of relevant state variables. We consider a state vector with two unobservable factors: the level (L_t) and slope (S_t) factors and that the vector of state variables follows a Gaussian VAR(1) process:

$$X_t = \mu + \Phi X_{t-1} + \Sigma \varepsilon_t \quad (1)$$

where ε_t are i.i.d shocks to the unobservable latent factors, Φ is a 2-by-2 lower triangular matrix, Σ is normalized to an identity matrix and X_t is the vector of latent variables. Each of these state variables is classified according to how shocks to the factor affect the shape of the yield curve. The level factor explains parallel shifts in the yield curve. Shocks to this factor

have similar effects over bonds across different maturities and thus induce changes in the level of the yield curve. The slope factor drives changes in the slope of the yield curve, with shocks to this factor affecting differently yields of shorter and longer maturities.

The second equation defines the one-period short term rate as a linear affine function of the latent factors:

$$i_t = \delta_0 + \delta_1 X_t \quad (2)$$

We assume further that no arbitrage exists in the bonds market, implying that there exists a positive stochastic discount factor, or pricing kernel that determines the price of all assets. In the context of bond pricing, the time t price of an n -period bond can be expressed as the product of the expected price of the same bond at $t+1$ discounted by the pricing kernel:

$$P_t^n = E_t(M_{t+1}P_{t+1}^{n-1}), \quad (3)$$

where P_t^n denotes the date t price of an n -period bond and M_{t+1} represents the stochastic discount factor. Alternatively, by iterating equation 3 forward and noting that the bond pays one unit at maturity, we can rewrite P_t^n as:

$$P_t^n = E_t[M_{t+1} \dots M_{t+n}] = E_t[\prod_{i=1}^n M_{t+i}], \quad (4)$$

implying that bond prices are a function of the evolution of the pricing kernel. It follows that we can model P_t^n , by modelling the evolution of the stochastic factor M_{t+i} . In the affine term structure framework the pricing kernel is assumed to follow a conditionally log-normal process: where λ_t are the market prices of risk related to the innovations of the state variables.

$$M_{t+1} = \exp(-i_t - \frac{1}{2} \lambda'_t \lambda_t - \lambda'_t \varepsilon_{t+1}) \quad (5)$$

Particularly, the market prices of risk correspond to the required compensation (premium) for exposures to the risk of “level” and “slope shocks”. We follow here the works of Constantinides (1992), Duffee and Singleton (2002) and Duffee (2002) in assuming that these market prices of risk can be modeled as a function of the vector of state variables:

$$\lambda_t = \begin{bmatrix} \lambda_L \\ \lambda_S \end{bmatrix} = \lambda_0 + \lambda_1 X_t \quad (6)$$

The transition equation for the state variables [1], the short rate equation [2] and the market prices of risk equation [3] combined form a Gaussian affine 2-factor model, where log bond prices ($p_t^{(n)}$), and accordingly continuously compounded bond yields (y_t^n) can be shown to be a linear affine function of the state variables:

$$y_t^n = -p_t^n/n = \tilde{A}_n + \tilde{B}_n' X_t \quad (7)$$

where:

$$A_{n+1} = -\delta_0 + A_n + B_n' (\mu - \lambda_0) + \frac{1}{2} B_n' B_n$$

$$B_{n+1}' = -\delta_1 + B_n' \Phi^*$$

$$\tilde{A}_n = -A_n/n \quad \tilde{B}_n' = -B_n/n$$

For a given set of observable yields, the likelihood function of this model can be calculated in closed form and the model's coefficients can be estimated by maximum likelihood using the Kalman Filter Procedure². We estimate this model using quarterly average zero coupon bond yields with maturities of 2, 3, 5, 7 and 10 years obtained from the Thomson Reuters database. Yields data for Germany are from 1980:1 to 2015:4, for Netherlands from 1988:1 to 2015:4 and for Spain and Italy from 1991:2 to 2015:4, according to data availability.

We decided to use two latent factors in our model because apparently it turns out that these are sufficient to capture most of the variability of bond yields for our sample. Actually, a principal component analysis shows that the first two principal components³ explain around 99,9% of the variation in the five bonds yields in all countries considered, thus pointing towards a negligible role of the third factor.

The parameter estimates results are presented in Table 1 in the appendix. The point estimates $\Phi(1,1)$ and $\Phi(2,2)$ show that both factors are very persistent with autoregressive

² The state space form of the two factor affine term structure model is described in detail in the appendix

³ Results of the principal component analysis are presented in the appendix

coefficients close to one and, except for some parameters related to the market prices of risk, most parameters turn out to be statistically significant at the 5% significance level. On the other hand, the small values of the measurement errors indicate that the model fits reasonably well the empirical yield curve, as illustrated in the graph 4 of figure 1 of the appendix, while graphs 1 and 2 lend credibility to our interpretation of the unobservable factors as level and slope factors as these show to be highly correlated to their empirical proxies: the ten year yield for the level factor and the yield spread for the slope factor.

3.2 Yield Spread Decomposition

The use of the affine term structure model setup allows us to decompose the yield of a zero coupon bond into two unobservable components:

$$y^n_t = \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} y^1_{t+i} \right] + y^n_t - \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} y^1_{t+i} \right] \quad (8)$$

The first component is an expectations component, whereby the n-period bond yield is an average of the current and future expected short term rates over the life of the bond. The second component is the term premium that compensates investors for holding longer term bonds. Investors will generally prefer shorter term bonds due to the higher interest rate risk and uncertainty of longer term bonds investment, and as such require an extra compensation in order to bear the extra risk of holding long term bonds⁴. The term premium will then capture the deviations of the observed bond yield from the expectations hypothesis implied yield. By subtracting the short term rate from the n period yield, the yield spread can be rewritten as:

$$y^n_t - y^1_t = \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} y^1_{t+i} \right] - y^1_t + y^n_t - \frac{1}{n} E_t \left[\sum_{i=0}^{n-1} y^1_{t+i} \right] \quad (9)$$

⁴ The compensation demanded for holding long term bonds depends on the amount and price of risk which may change with economic agent's perceptions of macroeconomic risk, such as the uncertainty about future inflation, real economic activity and the stance of monetary policy.

where the first component is the spread computed under the expectations hypothesis and the second component represents the term premium. This equation illustrates that yield spread movements can either be originated from changes in the future expected interest rates relative to current rates (expected spread) or simply by changes in the term premium demanded from investors to hold longer term bonds. Nevertheless, using the aggregate spread in our predictive regressions, we cannot differentiate between the effects of the expectations and term premium components and their possible different correlations with future GDP growth. To disentangle between these two effects, we can compute the expected component from the long term bond yield by assuming that the market prices of risk within the affine term structure model, λ_t , are zero. In those circumstances, investors are not earning any additional compensation for the exposure to level and slope shocks and thus the bond yield equals the average of the current and future short term yields. Accordingly we can compute the EH implied yield by replacing the estimated latent variables in equation 7 after removing the terms related to the market prices of risk⁵. Lastly, the term premium can be estimated as the difference between the observed yield and the implied EH yield, as suggested by equation 9.

4. The models and in-sample estimation

4.1 Predicting Recessions with the Yield Curve: Standard Probit Model

Following the previous studies of Estrella and Hardouvelis (1991) and Estrella and Mishkin (1998), we investigate the predictive content of the yield spread to forecast recessions in individual Euro Area countries. For that purpose, we use a probit model framework that directly estimates the probability of a recession at a given horizon based on the level of the spread. The dependent variable to be predicted by the probit model is a dummy variable R_{t+h} which takes the value of one if a recession takes place h quarters in the future and zero otherwise.

⁵ i.e. where $A_{n+1} = -\delta_0 + A_n + B_n' \mu + \frac{1}{2} B_n' B_n$ and $B_{n+1}' = -\delta_1 + B_n' \Phi$

The probability of a recession at time $t+h$, with a forecasting horizon of h quarters is given by the following equation:

$$P(R_{t+h} = 1) = \Phi(\beta_0 + \beta_1 SPREAD^{10Y-3M}_t + \beta_2 D_t) \quad (10)$$

where h ranges between 1 to 6 quarters, $\Phi(.)$ denotes the standard normal cumulative distribution function, $SPREAD^{10Y-3M}$ is the spread between the ten year bond yields and three month interbank rates and D_t is a dummy variable that tackles the structural break ⁶ between the yield spread and the recession dummy. According to Estrella and Mishkin (1998), the overlapping of forecasting horizons introduces serial correlation in the error terms in the form of a moving average of order $h-1$. The moving average does not affect the consistency of the probit model's coefficients but affects the consistency of the standard errors. We correct this bias using the Newey and West (1987) adjustment method by presenting standard errors and t-statistics corrected for serial correlation with a lag length of $h-1$.

The definition of a recession in the context our probit models is crucial to construct the dummy variable R_{t+h} . In the United States, the National Bureau of Economic Research (NBER) officially dates U.S recessions and defines recessions as periods of a significant decline in economic activity, spread across the economy and normally visible in a set of economy-wide measures of economic activity, including industrial production, employment and real GDP. Since in the Euro Area no official recession dates are available for individual Euro Area countries, we estimate recessions using the Bry and Boschan (1971) algorithm⁷, which underlies much of NBER's business cycles dating procedure. The Bry and Boschan algorithm identifies the turning points (peaks and troughs) of the business cycle as local maximums and local minimums (respectively) of the seasonally adjusted real GDP series,

⁶ D_t equals 0 before the structural break date and 1 afterwards. Structural Breaks will be further discussed in this paper

⁷ Details of the BBQ algorithm can be found in the appendix.

where a recession will be defined as the period between the trough and the peak of the cycle with a minimum duration of 2 quarters⁸.

4.2 Alternative Probit Models

We consider three alternative probit model specifications for forecasting BBQ recessions in the next h quarters. The first two probit models test the predictive content of the yield spread components and their potential different impacts over the likelihood of future recessions, as given by the following equations:

$$P(R_{t+h} = 1) = \Phi(\beta_0 + \beta_1 SPREAD_t^{adj.} + \beta_2 D_t) \quad (11)$$

$$P(R_{t+h} = 1) = \Phi(\beta_0 + \beta_1 SPREAD_t^{adj.} + \beta_2 TP_t + \beta_3 D_t) \quad (12)$$

where $SPREAD_t^{adj.}$ is the expectations components of the spread (or adjusted spread) and TP_t is the term premium component. The model in equation (12) allows for a different predictive content from each spread component. If both components turn out to be statistically significant predictors of future recessions, then a model that includes separately both effects is the most suitable and may contribute to improve the forecasting performance of the spread. If the term premium turns out to be statistically insignificant, though, it is contaminating the signal of the expectations component and removing it from the spread leads to better recession forecasts. In such case we should consider the model in equation (11), which includes the expected spread as a single explanatory variable.

Moreover, even considering the potential different roles of the spread components, it is not clear that the yield spread necessarily captures all the information of the yield curve. There is a priori no reason why a rise in the level of the current short term rates must have the same predictive content for the likelihood of a recession as a fall in the average expected future

⁸ The recession dates and the data description can be found in the appendix

interest rates, for example. To control for this effect, we consider augmenting the model in equation (12) with the level of the yield curve, proxied by the 3-month interbank rate:

$$P(R_{t+h} = 1) = \Phi(\beta_0 + \beta_1 SPREAD_t^{adj.} + \beta_2 TP_t + \beta_3 MMr_t + \beta_4 SPREAD_t^{adj.} \times MMr_t) \quad (13)$$

where MMr is the 3-month money-market rate and $SPREAD_t^{adj.} \times MMr_t$ is an interaction term that attempts to capture the nonlinear relationship between the spread and future recessions, based on the level of money market rate. Interactions in this respect would matter if a change in the spread has different implications for future recessions depending on the level of the money market rate.

Controlling for the level of the 3-month interbank rate can also be used to ascertain the influence of monetary policy on the predictive content of the spread and thus on whether the spread contains information beyond the actions of current monetary policy. If all the predictive content of the spread comes from its role as an indicator of monetary policy we expect that its predictive content disappears when we control for the effect of current monetary policy.

4.3 Results

Table 1 shows the estimation results of the recession probit models using the term spread and the expectations component as single explanatory variables (equations 10 and 11) and when the term premium is added as an additional explanatory variable to the adjusted spread (equation 12). Overall, the term spread appears to contain useful information about the likelihood of future recessions. The term spread coefficient enters significantly the term spread model in all countries for predictive horizons that go up to 4 quarters ahead, reaffirming the underlying historical association. The forecasting ability of the spread, however, deteriorates as the predictive horizon rises. The fit of the regression, measured from its Pseudo-R², drops significantly for longer horizons until it becomes almost negligible for 5 and 6 quarters ahead. Accordingly, at such horizons the term spread coefficient becomes statistically insignificant.

Using the yield spread decomposition, the results indicate that most of this predictive content comes from the expectations component of the spread rather than the term premium. The expectations component model results are very close to those of the term spread with estimated coefficients that are both negative and highly significant up to 4 quarters ahead. Conversely, the term premium component holds a marginal role in recession predictions. When we add the term premium as an additional regressor to the adjusted spread equation, its coefficient turns out to be statistically insignificant both at shorter and longer horizons and the fit of the regression does not show any substantial signs of improvement. We find, however, very little gains from extracting the term premium component from the term spread. This is possibly caused by the term premium carrying the same negative coefficient sign as the expectations component of the spread, which reduces its contamination effect over the yield spread predictive content.

Figure 1 illustrates this idea by presenting the recession fitted probabilities produced by the term spread and the expectations component probit models at the 2 quarter horizon. The actual BBQ recession dates are identified by the shaded regions. Observe that both models present overall a good fit, with recession probabilities that typically rise before actual recessions and remain low in non-recessionary periods. In line with the previous results, the expectations component and the term spread models track each other very closely with recession probabilities that are very similar between them, reinforcing the idea of a dominant role of the adjusted spread. An exception holds for Italy where adding the term premium appears to improve the recession forecasts of the adjusted spread model by increasing the odds of a recession before actual recessions occur, especially during the 2008:1 and 2011:2 recessions.⁹

⁹ This reconciles with the previous results in Table 1 for Italy where the term premium component is statistically significant up to 3 quarters ahead

The yield curve model, which controls for the level of the term structure, appears to improve the performance of the yield spread probit model, especially at shorter predictive horizons. The results in table 2 show that, overall, the 3 months rate is statistically significant and associated with a higher likelihood of future recessions, as expected, though the yield spread predictive content is not statistically related to the level of the 3-month rate given the insignificance of the interaction term. Moreover, the forecasting ability of the yield spread, through its expectations component, remains significant after controlling for the level of the yield curve. The estimates on the coefficient of the adjusted yield spread are statistically and economically significant in all the countries where the spread was also found to be statistically significant in Model 3. Nevertheless, the predictive power of the adjusted spread appears to deteriorate relative to the model in equation 13, especially at the longer forecasting horizons, suggesting that some of this predictive power may reflect the actions of current monetary policy.

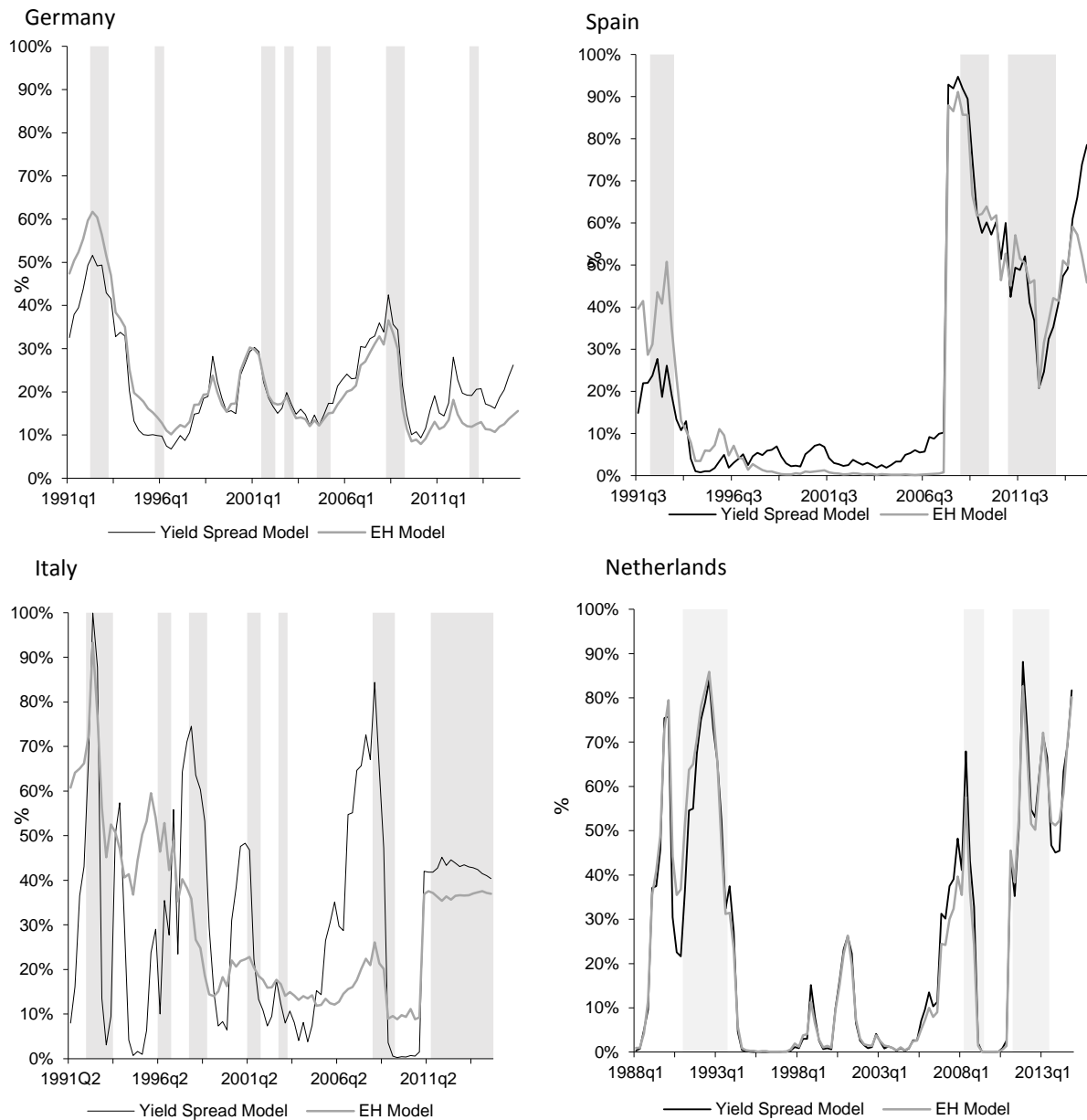
5. Structural Break Testing

The issue of instability in the predictive content of the yield spread for real activity has gained relevance in the most recent studies in the literature. This shift in attention has been motivated by recent findings documenting the existence of structural changes in the relationship between the yield spread and real economic activity in the U.S and Euro Area countries, namely in the form of a diminished performance of the term spread to forecast output growth since around the 1980s¹⁰. This forecast breakdown of the yield spread predictive content has been ascribed to the significant decrease in volatility in output and other macroeconomic variables associated with the Great Moderation Period, which naturally decreased the detectability of this relationship. (See Chinn and Kucko 2010)

¹⁰ See e.g. Giacomini and Rossi (2006) and Estrella, Rodrigues and Stich (2003) for evidence in the U.S and Duarte, Venetis and Paya (2005) for evidence in the Euro area.

Figure 1: **Probability of a Recession 2 quarters ahead from Alternative Probit Models**

(BBQ recessions are shown by the shaded regions)



According to Kucko and Chin (2010) this reduction in macroeconomic risk is precisely what explains the significant decline in the term premium during the Conundrum period, which prevented long term interest rates to rise along with short term rates to signal a period of continuing economic growth. From a different perspective these structural changes in the predictive models might also be related to changes in the monetary policy behaviour of central banks and their reactions to economic conditions. In this respect, Estrella (2005) explores

within a rational expectations macroeconomic model the specific circumstances under which the yield curve has predictive content for output and demonstrates that the relationship between the spread and economic growth depends on the policymakers reaction function between inflation and output deviations from target. Particularly, when monetary authorities attach a higher weight to the inflation target (relative to the output gap), the predictive content of the spread tends to weaken¹¹. Following this theoretical argument, it is expectable that the yield spread proves to be a better forecaster of future economic growth when monetary authorities' preferences are towards stabilizing output over inflation, which are typically periods of high inflation persistence.

Against this background of structural instability, the use of the yield spread as a forecasting tool must be regarded with caution and it is advisable to test for the stability of the model if it is to be used for forecasting purposes. In what follows, we test for structural breaks in the yield spread model as specified in Model 1 for 2,4 and 6 quarters ahead.

To have a visual idea of the potential relevance of the parameters change, we start by estimating the probit model's coefficients recursively for each of the countries in our dataset. We start with a minimum initial sample size of 5 years and then extend the sample quarter by quarter until the full sample is estimated. Figure 2 plots the recursive coefficients of the yield spread probit models for future recessions 2,4 and 6 quarters ahead¹², with the dates on the horizontal axis determining the end date of the sample period. The recursive estimation of the coefficients suggests the existence of some stability problems in the latter part of the sample. It looks as if the yield spread coefficient faces a sudden significant increase around the financial

¹¹ This argument reconciles with the findings of Bordo and Haubrich (2004,2008) that the yield spread tends to predict better economic growth during periods of high inflation persistence than in periods of low and stable inflation where inflation shocks tend to change more near term inflation than long term expected inflation and thereby distort the informational signal of the nominal yield spread

¹² The results for the stability tests with the expected yield spread are very similar to the ones obtained with the simple yield spread, which is consistent with the our previous results that point towards a marginal role of the term premium. For that reason we do not report these results. The results for the stability tests of the yield spread model with the remaining horizons were also estimated and can be found in the appendix

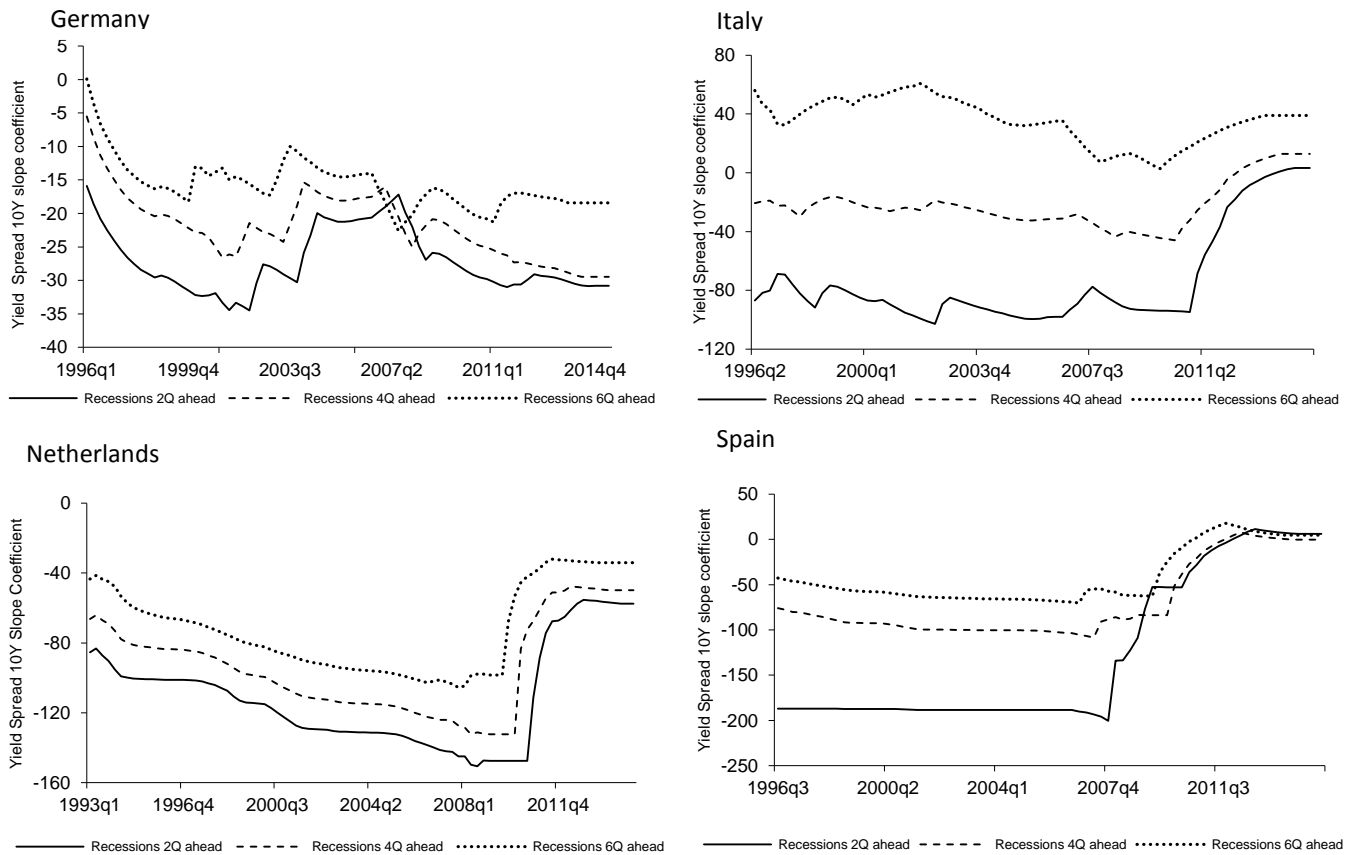
crisis era in Italy, Spain and Netherlands, after an apparent period of broad stability in the yield spread-recessions relationship. In Italy and Spain, inclusively the yield spread coefficient turned positive, reversing the apparent negative relationship expected between the yield spread and the likelihood of future recessions. For the recession's predictions further out, we find rather similar recursive coefficients but with less pronounced shifts in the coefficient the longer is the forecasting horizon.

These visual indications of instability are corroborated by formal structural break tests for a single unknown break point during the sample period. Table 5 in the appendix shows the p-values for the Sup-LR (Andrews 1993) and Exp-W-LR (Andrews and Ploberger 1994) test statistics for the optimal break dates in the predictive probit models¹³. The tests reject the null hypothesis of no structural break changes during the full sample in Italy, Spain and Netherlands across all the forecasting horizons at a 5% significance level. In line with the visual results, the break dates occur around the financial crisis period and the longer the prediction horizon, the higher the p-values and thus the weaker the evidence for a structural break, which is consistent with the findings that the longer the prediction horizon, the less pronounced were the shifts in the spread coefficient. This disruption in the yield spread coefficients might be explained with the deterioration of the monetary policy mechanism after the financial crisis¹⁴. With the outbreak of the financial crisis the conventional monetary policy instruments became ineffective in affecting the bank's prime lending rates and the real economy. As the crisis accelerated the central banks dropped their main rates nearly to zero in an attempt to stimulate the economy, but the bank's lending rates soared as the risk premium increased sharply, thereby

¹³ The technical details of the Sup-LR tests and Exp-W-LR tests can be found in Andrews (1993) and Andrews and Ploberger (1994), respectively.

¹⁴ See Salachas et al (2014). According to Salachas et al the only exception to the breakdown between monetary policy instruments and the prime lending rates during the financial crisis was Germany. In Germany the positive relationship between the two rates maintained even under the financial crisis period. This result supports our findings for the existence of no structural breaks in Germany around the financial crisis period.

Figure 2: Forecasting Recessions, Expanding Windows (Beta Coefficients)



distorting the mechanism by which monetary policy decisions affected the real economy through the banking channel. To the extent that most of the predictive content of the yield spread reflects the effects of monetary policy decisions, we expect a deterioration of its predictive content with the breakdown of the monetary policy transmission mechanism.

6. Conclusion

This paper provides further empirical evidence on the usefulness of the yield curve spread to predict future recessions in Euro Area countries. We use a two factor affine term structure model to decompose the yield spread into an expectations hypothesis and term premium components and assess the individual contributions of each of the spread's components in forecasting recessions. Our empirical analysis finds that most of the predictability of the spread comes from the expectations component rather than the term

premium, which turns out to play a marginal role in recession's predictions. When we compare the historical recession forecasting performance of the term spread and its expectations component, we find that the term spread and the adjusted spread models follow each other very closely in terms of model fit, but apparently no significant gains can be achieved by removing the contaminant effect of the term premium from the spread. Our results show that although part of this predictability of the expectations component is related to the effects of monetary policy, the yield curve contains informational content beyond the stance of monetary policy.

The forecasting relationship of the yield spread is not necessarily stable over time, however, and against such background of structural instability the model's results must be regarded with caution and tested for eventual structural breaks. We use the Sup- LR and Exp- W-LR statistics to test for structural breaks with a single unknown break point in our sample period. Our results show that after a period of broad stability the yield spread predictability deteriorated with the outbreak of the financial crisis. We argue that this disruption of the yield spread coefficients might be explained by the unusual time varying risk premium which deteriorated the mechanism by which monetary policy decisions affected the real economy through bank lending rates.

7. References

- Ang, A., and M. Piazzesi. 2003. "A no arbitrage vector autoregression of term structure dynamics with macroeconomic and latent variables". *Journal of Monetary Economics*, Vol. 50: 746-787
- Ang, A., M. Piazzesi, and M. Wei. 2006. "What does the yield curve tell us about GDP growth?" *Journal of Econometrics*, Vol. 131: 359-403
- Augustín, D., I.A. Venetis, and I. Paya. 2005 "Predicting real growth and the probability of a recession in the euro area using the yield spread". *International Journal of Forecasting*, Vol. 21: 261-277
- Bernard, H., and S. Gerlach. 1996. "Does the Term Structure predict Recessions? The International Evidence", Working Paper, Bank for International Settlements
- Bordo, D.M., and J.G. Haubrich. 2004. "The Yield Curve, Recessions and the Credibility of the Monetary Regime: Long Run Evidence 1875-1997", Working Paper, National Bureau of Economic Research
- D.W.K. Andrews. 1993. "Test for parameter instability and structural change with unknown change point". *Econometrica*, Vol. 61: 821-856
- D.W.K. Andrews, and W. Ploberger. 1994. "Optimal tests when a nuisance parameter is present only under the alternative". *Econometrica*, Vol. 62(6): 1383-1414
- Estrella, A., and G. Hardouvelis. 1991. "The term structure as a predictor of real economic activity." *Journal of Finance*, Vol. 46: 555-576
- Estrella, A., and F. Mishkin. 1998. "Predicting U.S. Recessions: Financial Variables as Leading Indicators", Working Paper, National Bureau of Economic Research
- Estrella, A., A. Rodrigues, and S. Schich. 2003. "How stable is the predictive power of the yield curve? Evidence for Germany and the United States." *Review of Economics and Statistics*, Vol. 85: 629-644
- Estrella, A. 2005. "Why does the yield curve predict output and inflation?" *The Economic Journal*, Vol. 115: 722-744
- Giacomini, R., and B. Rossi. 2006 "How stable is the forecasting performance of the yield curve for output growth?" *Oxford Bulletin of Economics and Statistics* Vol. 68(1): 783-795
- Hamilton, D.J., and D.H. Kim. 2002. "A reexamination of the predictability of economic activity using the yield spread." *Journal of Money, Credit and Banking*, Vol. 34(2): 340-360
- Kouretas, G., T. Laopodis, and E. Salachas. 2014. "The Monetary Policy in the Euroarea, United Kingdom and the USA: Evidence from financial crisis period." Working Paper, Athens University of Economics and Business
- Kozicki, S. 1997 "Predicting real growth and inflation with the yield spread" *Federal Reserve Bank of Kansas City Economic Review*, 39-57
- Kremer, M. and T. Werner. 2006. "Do term premia affect the predictive power of the German yield curve for future economic activity?" Working Paper, European Central Bank
- Moneta, F. 2003. Does the yield spread predict recessions in the Euro Area? Working Paper, European Central Bank
- Newey, W.K. and K.D. West. 1987 "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix." *Econometrica*, Vol. 55: 703-708
- Rosenberg, V.J., and S. Maurer. 2008. "Signal or Noise? Implications of the Term Premium for Recession Forecasting". *Journal of Economic Review*. Vol. 14: 1-11.
- Stock, H.J., and M. W. Watson. 1989. "New Indexes of Coincident and Leading Economic Indicators." Working Paper, National Bureau of Economic Research
- Wright, H. J. 2006. "The yield curve and predicting recessions". Working Paper, Federal Reserve Board

Appendix

Table 1.1: Probit Models results for forecasting recessions using the yield spread and the term premium (Germany and Spain)

K Quarters Ahead	Term Spread Model				EH Model				EH+TP Model					
	β_0	β_1	t-Stat	Pseudo R ²	β_0	β_1	t-Stat	Pseudo R ²	β_0	β_1	t-Stat	β_2	t-stat	PseudoR ²
Germany														
1	-0,43	-34,54	2,74***	0,08	-0,99	-27,90	3,12***	0,10	-1,08	-25,94	1,92*	5,56	0,19	0,10
2	-0,48	-30,79	1,88*	0,06	-1,01	-25,83	2,53**	0,09	-1,18	-21,90	1,31	11,4	0,32	0,09
3	-0,52	-30,09	1,70*	0,06	-1,02	-23,75	2,11**	0,07	-1,02	-23,65	1,27	0,27	0,01	0,07
4	-0,52	-29,45	1,67*	0,06	-1,01	-23,46	1,96**	0,07	-1,04	-22,79	1,23	1,96	0,05	0,07
5	-0,54	-26,30	1,53	0,05	-1,00	-22,06	1,67*	0,06	-1,17	-18,12	1,04	11,46	0,32	0,06
6	-0,64	-18,40	1,17	0,02	-0,96	-15,83	1,30	0,03	-1,14	-11,95	0,71	11,33	0,35	0,03
Spain														
1	-1,33	-23,54	2,19**	0,30	-2,90	-44,22	3,21***	0,38	-5,39	-56,83	2,37**	43,86	1,35	0,41
2	-1,30	-35,79	1,72*	0,36	-3,15	-50,13	3,11***	0,42	-3,57	-51,28	3,37***	8,82	0,45	0,42
3	-1,31	-63,41	2,57**	0,48	-4,00	-68,80	3,39***	0,50	-3,00	-67,32	3,57***	-22,06	1,04	0,51
4	-1,28	-61,81	2,88***	0,46	-2,94	-47,42	2,62***	0,42	-1,71	-61,35	3,37***	-48,12	1,62	0,47
5	-1,25	-44,00	2,21**	0,39	-2,28	-30,37	1,90*	0,33	-1,25	-44,02	2,23**	-43,89	1,23	0,39
6	-1,26	-31,64	1,81*	0,31	-1,88	-17,95	1,18	0,25	-0,99	-29,95	1,60	-38,95	1,09	0,31

Notes: The table reports the coefficient estimates, Mc-Fadden Pseudo-R² and the t-statistics from the maximum likelihood estimation of the probit models over 1 to 6 quarters ahead. The sample is quarterly from 1991:1-2015:2, as referred in the appendix. T-statistics are corrected for serial correlation created from the overlapping of the forecasting horizons as well as conditional heteroskedasticity with lag length of h-1, as suggested by Newey and West (1987).

Table 1.2: Probit Models results for forecasting recessions using the yield spread and the term premium (Italy and Netherlands)

K Quarters ahead	Term Spread Model				EH Model				EH+TP Model					
	β_0	β_1	t-Stat	Pseudo R ²	β_0	β_1	t-Stat	Pseudo R ²	β_0	β_1	t-Stat	β_2	t-stat	PseudoR ²
Italy														
1	0,06	-52,39	3,27***	0,29	-0,74	-22,07	2,79***	0,25	-0,15	-60,07	3,39***	-44,73	2,60***	0,31
2	0,48	-94,72	4,38***	0,29	-0,82	-29,32	3,75***	0,14	0,20	-117,17	3,93***	-91,55	3,69***	0,35
3	0,26	-66,37	3,35***	0,18	-0,75	-27,45	3,26***	0,13	-0,02	-78,57	2,83***	-57,42	2,48**	0,24
4	-0,08	-32,23	1,95*	0,06	-0,67	-22,85	2,31**	0,09	-0,39	-38,93	1,86*	-19,80	0,95	0,11
5	-0,47	-0,29	0,02	0,01	-0,57	-11,75	1,14	0,03	-0,74	-3,46	0,21	11,03	0,54	0,03
6	-0,72	17,57	0,99	0,02	-0,52	-5,41	0,54	0,01	-0,91	14,33	0,82	25,88	1,13	0,04
Netherlands														
1	-0,43	-108,71	4,41***	0,41	-1,88	-85,77	4,59***	0,41	-1,40	-94,42	2,97***	-37,13	0,34	0,41
2	-0,37	-106,01	3,78***	0,39	-1,79	-84,16	3,54***	0,39	-1,53	-88,74	2,84***	-19,58	0,14	0,39
3	-0,34	-82,38	3,13***	0,31	-1,46	-66,94	2,89***	0,31	-1,64	-64,13	2,35**	13,08	0,09	0,31
4	-0,33	-66,11	2,49**	0,24	-1,23	-53,76	2,24**	0,24	-1,25	-53,43	2,18**	1,58	0,01	0,24
5	-0,36	-50,11	1,91*	0,16	-1,06	-41,40	1,74*	0,16	-1,23	-38,85	1,78*	13,01	0,08	0,16
6	-0,40	-38,41	1,46	0,10	-0,93	-31,94	1,33	0,10	-1,12	-29,35	1,33	13,51	0,08	0,10

Notes: The table reports the coefficient estimates, Mc-Fadden Pseudo-R² and the t-statistics from the maximum likelihood estimation of the probit models over 1 to 6 quarters ahead. The sample is quarterly from 1991:1-2015:2, as referred in the appendix. T-statistics are corrected for serial correlation created from the overlapping of the forecasting horizons as well as conditional heteroskedasticity with lag length of h-1, as suggested by Newey and West (1987).

Table 2: **Predicting future recessions with the level and the term spread of the yield curve**

$$P(R_{t+h} = 1) = \Phi(\beta_0 + \beta_1 SPREAD_t^{adj.} + \beta_2 TP_t + \beta_3 MMr_t + \beta_4 SPREAD_t^{adj.} \times MMr_t)$$

K (quarters ahead)	β_0	β_1	t-Stat	β_2	t-Stat	β_3	t-Stat	β_4	t-Stat	Pseudo-R ²
Germany										
1	-0,75	71,42	0,61	-193,34	0,74	106,27	0,75	-206,02	0,60	0,11
2	-1,34	-71,53	0,81	129,00	0,61	-64,71	0,59	-20,92	0,05	0,09
3	-1,33	-124,04	1,19	189,29	0,76	102,02	0,82	272,86	0,66	0,08
4	-1,23	-56,19	0,45	9,88	0,03	2,37	0,02	505,10	1,24	0,09
5	-1,47	-58,50	0,47	13,71	0,05	9,17	0,06	687,18	1,72*	0,10
6	-1,54	-87,40	0,77	88,22	0,39	-31,26	0,25	747,37	1,83*	0,08
Spain										
1	10,37	222,92	2,72***	15,53	0,29	140,76	3,03***	-573,21	1,34	0,64
2	-5,56	257,94	2,97***	-56,70	-1,56	160,38	3,31***	-242,49	0,66	0,67
3	-8,12	92,70	1,57	-77,13	1,53	180,59	2,94***	917,34	1,53	0,66
4	-3,80	22,84	0,44	-63,41	-2,25**	89,45	2,01**	555,68	1,23	0,51
5	-1,51	9,83	0,20	-52,80	-2,06**	27,24	0,78	-34,02	0,09	0,40
6	0,11	-35,64	0,71	-57,24	1,95*	-27,66	0,44	-418,56	0,99	0,32
Italy										
1	-3,54	136,50	2,67***	68,03	3,42***	71,48	2,50**	-1999,43	3,71***	0,51
2	-5,67	219,97	3,59***	106,43	3,67***	124,30	3,29***	-3518,89	3,58***	0,55
3	-7,33	287,24	3,80***	120,95	3,53***	160,65	3,49***	-3740,22	3,40***	0,52
4	-2,23	79,82	1,06	49,96	1,92	34,22	0,73	-788,63	1,11	0,44
5	-2,16	79,93	1,35	44,00	1,88	28,96	0,83	-274,25	1,32	0,36
6	-1,91	73,06	1,14	49,74	1,91	19,89	0,52	-180,58	0,95	0,30
Netherlands										
1	1,24	-75,82	2,39**	-381,37	1,98**	55,58	2,23**	-550,21	0,58	0,46
2	0,55	-72,73	2,17**	-287,20	1,50	43,18	1,92*	-328,45	0,23	0,42
3	-0,01	-52,48	1,70*	-194,00	0,98	33,03	1,42	-727,64	0,57	0,34
4	0,29	-44,10	1,55	-196,61	0,85	31,36	1,41	-1289,74	1,23	0,29
5	0,03	-31,59	1,25	-147,93	0,75	25,22	1,27	-1386,95	1,22	0,23
6	-0,23	-24,48	0,96	-98,76	0,51	17,46	0,92	-1444,84	1,20	0,17

Notes: R_{t+h} is a recession dummy that takes the value of 1 if and only if a recession takes place h quarters ahead, h is the forecasting horizon, $SPREAD_t^{adj.}$ is the spread adjusted for the Ten year term premium ($SPREAD_t^{adj.} = SPREAD_t - TP_t$), MMr_t is the 3 month money market rate and $SPREAD_t^{adj.} \times MMr_t$ is an interaction term that captures the nonlinear relationship between the spread and future recessions, based on the level of the money market rate. T-statistics are constructed using Newey West standard errors to correct for serial correlation and conditional heteroskedasticity with lag length of h-1, as suggested by Newey and West (1987)